

# ITS Concept of Operations: Work Zone Intrusion Warning System (WIWS)

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## Acknowledgements

This document was prepared for Minnesota Department of Transportation's (MnDOT) Systems Engineering to Address Work Zone Challenges project.

## Project Champion

Rashmi Brewer is the MnDOT project champion for this effort. MnDOT stakeholders were heavily involved in identifying the key challenges with using Intelligent Transportation Systems to address and enhance safety, operations, mobility and efficiency in work zones. This document covers the concept of operations requirements to address some of these challenges.

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# 1. Introduction

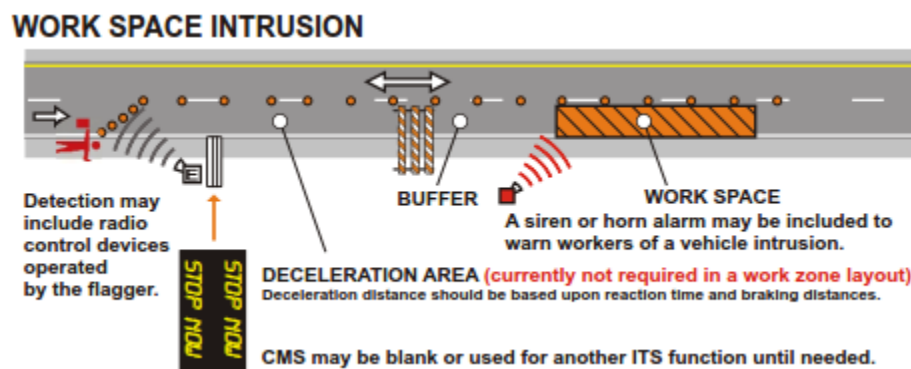
Safety is MnDOT's top priority as demonstrated in the Toward Zero Deaths (TZD) initiative to lower the number of traffic crashes, injuries, and deaths occurring on Minnesota roads. MnDOT is working to not only increase safety for drivers, yet also for those in the field working to improve our roadway system. Roadway work, for the purpose of the concept of operations, includes construction and maintenance work. In the state of Minnesota, 21 severe crashes occur in the work zone in a typical year. MnDOT stakeholders have identified that drivers are not adequately complying with work zone messages and are entering restricted work zone areas. Vehicles that enter work zones place a potential threat to the lives of construction workers as well as drivers and passengers. Stakeholders have identified a need for a system that would warn roadway workers and alert intrusive vehicles in the event that a vehicle enters the restricted work zone.

## 1.1 System Overview

Work zone layouts intend to provide safety to workers, allow sufficient space for the roadway work, and provide signs and/or messaging systems that improve roadway safety and inform motorists. MnDOT stakeholders have determined the need for additional system components to improve safety for travelers and construction workers. The MnDOT Intelligent Work Zone (IWZ) Toolbox contains a Work Intrusion Warning System (WIWS) to alert roadway workers when an intrusive vehicle enters the work zone (see Figure 1). Adding alerts to the vehicle that entered the work zone with an audible alarm could improve the current system. Additionally, there has been an issue with distracted and careless drivers not complying with the work zone and roadway messaging, causing them to enter the restricted work zones. MnDOT stakeholders have identified that these areas require supplemental enforcement to penalize violators whom intentionally ignore work zone messaging. A surveillance system would serve to monitor driver behavior when vehicles intrude the work zone. Once law enforcement determines that a work zone intrusion has occurred, law officials can observe the driver's behavior and move forward with consequences if necessary.

The IWZ Toolbox serves to guide Contractors to select a suitable ITS system to improve safety for drivers and vehicles in construction areas. The toolbox does not require Contractors to include a WIWS in their work zone. Roadway projects should consider implementing the WIWS since Stakeholders have identified work zone intrusion as a primary issue. The WIWS will greatly enhance safety for both workers and the drivers which should further prevent any injuries.

**Figure 1 Typical Work Space Intrusion Warning System Configuration**



## 1.2 Stakeholders

Stakeholders will need to collaborate in order to determine how to implement this system. The four primary groups that will interact and have responsibilities with the WIWS are:

- **Drivers** on any roadway where construction occurs
- **Industry and Field Personal** who may design, construct, and work on road construction throughout the state of Minnesota
- **Transportation agencies** at the state, county, and local level that will identify work zone related challenges, oversee, monitor, and research conditions in the work zones; and,
- **Law enforcement** who may observe operation, driver compliance, and safety of solutions in the work zones

MnDOT is working to improve safety in work zones and to reduce work zone intrusions by vehicles. A Concept of Operations will clearly convey the fundamental needs and concept of the systems. This Concept of Operations details ways of improving the current systems in place. The remainder of this document identifies the needs of the noted stakeholder groups, describes an operational concept from the stakeholder perspectives, outlines systems components, and presents common operational scenarios for this challenge.

## 2. Needs

Stakeholders have identified re-occurring work zone challenges that need a better understanding and approach to reduce their impacts to travelers and workers. The Stakeholders have developed the needs for these challenges. Each challenge corresponds with an operational system need that will determine what the WIWS must accomplish. The table below summarizes the challenges and needs.

Challenge	ID	Need
Drivers are not complying with work zone messages and entering restricted work zone areas.	1	Workers need an alert when vehicle enters area, new systems needed to alert drivers.
Vehicles unintentionally leave the travel lanes and enter the restricted work zone putting workers at risk.	2	Workers and drivers need an alert when vehicle crosses into restricted area.
Drivers are inattentive and do not pay attention to messages.	3	Ability to transfer information to travelers so that it is effective.
Drivers are intentionally ignoring work zone traffic control (flaggers, advance devices) leading to unsafe operations.	4	Increase worker safety by improving enforcement where drivers intentionally ignore messages/work zone traffic control.
In work zone zones with pilot cars, traffic can enter at midpoints from driveways or side roads and go the wrong way.	5	Agency or contractor must consider all points of entry during unconventional traffic movement and deploy systems to alert drivers.

### 3. Operational Concept

This section describes how the WIWS will involve various stakeholders. The following operational concept narrates events and responsibilities of each stakeholder group. The concept describes how stakeholders should interact with WIWS and references the stakeholders' needs.

#### 3.1 Driver Perspective

3.1.1 Drivers approaching a work zone area will see signs at sufficient locations, warning them that they are reaching a work zone area. Refer to the MN MUTCD including the Field Manual or the TTC Layout Templates for typical layout examples. (3)

3.1.2 If a vehicle unintentionally leaves the travel lane and enters the work zone, a detection system will trigger a "STOP NOW" portable changeable message signs (PCMS) to flash and activate a siren or horn alarm. This system will alert the driver that they have entered a restricted area, raising safety awareness. (1) (2)

3.1.3 Drivers will see the alert at a distance sufficient to allow enough time for the driver to react safely. A deceleration area, distance based on reaction time and breaking distance, will provide the driver ample distance to safely exit the work zone without putting workers at risk. A buffer area between the deceleration area and the work space will counteract drivers with poor reaction time. (1) (2)

3.1.5 If cameras have identified a driver whose behavior displays that they have been ignoring work zone traffic control, the intrusive driver will face fines or other punishments. (4)

#### 3.2 Transportation Agency Perspective

3.2.1 Transportation agencies will require an ITS configuration in a way that uniformly denotes work zone conditions, traffic control, and advisory messages. (1) (2) (5)

3.2.2 Transportation agencies will inspect Contractors' layout of WIWS and ensure that it complies with their standards. (1)(2) (5)

3.2.3 To help drivers recognize the WIWS configuration as a warning system, transportation agencies will deploy the system consistent with warning sign standards and guidance in the MN MUTCD. (1) (2) (3) (4) (5)

3.2.4 To inform drivers of WIWS audible alerts across jurisdictions, transportation agencies will deploy a system with uniform placement, sign combinations, and audible alerts throughout their jurisdiction. (1) (2) (3)

3.2.5 MnDOT's Regional Transportation Management Center (RTMC) will receive an alert when a driver activates the WIWS in the Twin Cities Metro area. (1) (2) (3) (4)

#### 3.3 Industry and Field Personal Perspective

3.3.1 Industry will follow MnDOT's standards in regards to the layout requirements for the WIWS. (1) (2)

3.3.2 Industry will test and ensure the system satisfactorily meets the performance requirements. (1) (2)

3.3.3 Industry will use information which the detection devices collect to make system improvements to the system both in planning and operations phases of work zones. (1) (5)

3.3.4 Industry will understand and be alerted to the system's performance through records of system failure and vehicle detection. (5)

3.3.5 Industry will have training, documentation, and technical ability to install and maintain a WIWS.

3.3.6 Industry will communicate with residents whose driveways exit onto the work zone and educate them on how the WIWS performs. (5)

### **3.4 Law Enforcement Perspective**

3.4.1 WIWS will record when vehicles enter the work zone to analyze if the driver behavior was reckless and/or intentional. (4)

3.4.2 Law enforcement will receive alerts when a vehicle enters the work zone. (4)

3.4.3 Law enforcement will observe work zone operations in a manner consistent with warning sign standards and guidance in the MN MUTCD. It will ensure that the work zone conflict warning system operates in a manner consistent with warning sign standards and guidance in the MN MUTCD. (3) (4)

3.4.4 Law enforcement will observe uniform work zone warning system placement, sign combinations and alerts through their jurisdiction to discern how well drivers understand the work zone conflict warning system alerts across agency jurisdictions. (1) (3) (4) (5)

## **4. System Components**

Work Zone Intrusion Warning System components include all the physical parts of the system that work together to provide alerts to the drivers that enter a restricted area and to workers in the work zone. The following is an overview of the system components for WIWS:

- Detection: Detect vehicle presence and flow of traffic.
- Warning: Dynamically activates when an unwanted vehicle enters a work zone. This may include changeable message signs, flashing beacons, and sirens.
- System Communication: Transmits data among other components (e.g. detection and warning).
- Data Management: Store system performance data.
- System Monitoring: Components used to operate, detect and report fluctuations in system performance.

## 4.1 System Component Support and Responsible Parties

Component	Support Required
<i>Overall WIWS</i>	Determine where components of the WIWS should be installed based on traffic volume, speeds, roadway configuration, and work zone characteristics for maximum safety effectiveness. (3.2.2, 3.3.1)
	Locate advance warning signs and other standard temporary traffic control devices in compliance with the MUTCD standards. (3.2.3, 3.3.1)
	Incorporate routine inspection and maintenance of WIWS into the agencies' standard practices. (3.2.2, 3.2.4)
<i>Detection</i>	Install detection equipment and connect to power and other WIWS components. (3.3.1, 3.3.2, 3.3.5)
	Install and integrate detection with system communication to connect detection to the audible alert warning, data management and system monitoring. (3.3.1, 3.3.5)
	Inspect periodically to determine if detection is functioning as intended. (3.2.2, 3.3.2)
	If detection is not functioning, follow procedures to troubleshoot and restore functionality. (3.3.2, 3.3.3)
<i>Warning</i>	Install warning equipment and connect to power and other WIWS components. (3.3.1, 3.3.2, 3.3.5)
	Inspect periodically to determine if warnings are functioning as intended. (3.2.2, 3.3.2)
	If warning system is not functioning as intended, follow procedures to troubleshoot and restore functionality. (3.3.2, 3.3.3)
<i>System Communication</i>	Install and connect system with communication equipment with other WIWS components. (3.3.1, 3.3.2, 3.3.5)
	Inspect regularly to determine if communication is functioning as intended. (3.2.2, 3.3.2)
	If system communication is not functioning as intended, follow procedures to troubleshoot and restore functionality. (3.3.2, 3.3.3)
<i>Data Management</i>	Install and connect data management equipment to other ICWS components. (3.3.1, 3.3.2, 3.3.5)
	Periodically download data from storage device following procedures. (3.3.3, 3.3.4)
	Inspect periodically to determine if data management is functioning as intended. (3.2.2, 3.3.2)
	If system communication is not functioning as intended, follow procedures to troubleshoot and restore functionality. (3.3.2, 3.3.3)
<i>System Monitoring</i>	Install system monitoring equipment and connect to other WIWS components. (3.3.1, 3.3.2, 3.3.5)
	Inspect periodically to determine if system monitoring is functioning as intended. (3.2.2, 3.3.2)
	If system monitoring is not functioning, follow procedures to troubleshoot and restore functionality. (3.3.2, 3.3.3)

## 5. Operational Scenarios

The following operational scenarios elaborate the individual challenges that the WIWS will address for an urban interstate and rural road conditions.

## 5.1 Urban Interstate

Each example assumes that there is a 2 lane closure along an interstate where construction crews are reconstructing a portion of the interstate (see Figure 1). Varying construction equipment is present, with approximately 6-8 individuals on site including the Contractor and Inspector.

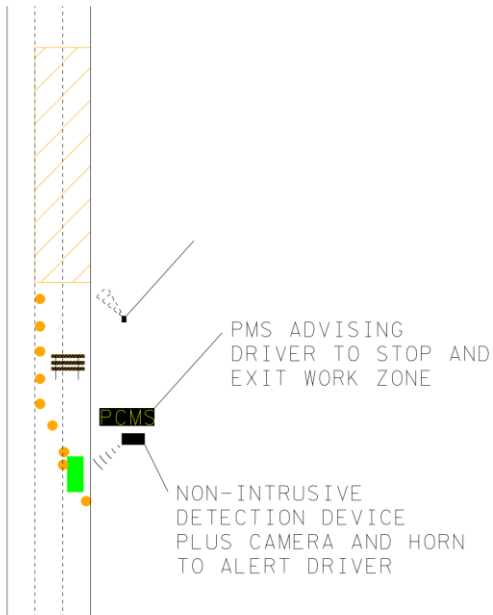


Figure 1 Urban Multi-lane Roadway Example

### 5.1.1 Workers Need an Alert When Drivers Enter Work Zone

As drivers approach a work zone area, signs will warn drivers at an adequate distance from the work zone. The Contractor shall place signs in accordance with the MN MUTCD. The detectors of the WIWS will activate when a vehicle unintentionally enters the work zone. The system will sound an alarm that will alert workers that an intrusive vehicle has entered the work zone. Simultaneously, detectors will trigger another siren and a flashing PCMS sign alerting the driver that they have entered a restricted area. A deceleration area near the work zone entrance will provide space for drivers to safely avoid further conflict. The system will record the incident with Work Zone Intelligent Cameras. At the time of the incident, MnDOT's RTMC Operations will be alerted to review the recording of the incident. If the driver is able to exit the work space safely without injuring workers, intervention from enforcement will not be necessary. If the driver displays reckless driving and exits the work zone, the RTMC will record the vehicle's characteristics (i.e. car make and license plate) and notify law enforcement.

### 5.1.2 Distracted Drivers Need an Alert When They Enter a Work Zone

A distracted driver is driving through the construction zone and is responding to a text message. The driver continues to not pay attention to the warning signs while they carelessly enter the work zone. The detectors of the WIWS will be activated and will sound an alarm that will alert workers that a vehicle has entered the work zone. The driver will hear a siren/horn and become aware that they have entered a restricted work zone. The driver will see a flashing PCMS sign warning them to stop their vehicle. The driver will have sufficient time to slow down in the deceleration area before they affect the safety of the

workers. Therefore, the driver will be able to exit back onto the roadway. The system will record the incident with Work Zone Intelligent Cameras. MnDOT's RTMC Operations will be alerted to review the recording of the incident.

### 5.1.3 Law Enforcement Should Be Increased to Deter Reckless Driving

During rush hour, a reckless driver enters the work zone to drive around the slow traffic. The detectors of the WIWS will activate and sound an alarm to warn workers that an intrusive vehicle has entered the work zone. Simultaneously, detectors will trigger another siren and a flashing PCMS sign alerting the driver that they have entered a restricted area. The driver continues to carelessly drive through the deceleration area and exits at the end of the work zone. Workers present at the work zone will contact 911 and report the incident. The system will record the event with Work Zone Intelligent Cameras. At the time of the incident, MnDOT's RTMC operations will be alerted to review the recording of the incident. Operators at the RTMC will acknowledge the driver's reckless behavior and notify law enforcement to intervene immediately after the incident. The RTMC operators will be able to provide law enforcement with the recording, characteristics of the car, and license plate.

## 5.2 Rural Road

The following example assumes that a segment of one lane is closed for construction along a 2 lane rural county road. Roadway workers are reconstructing a portion of the county road (see Figure2). Varying construction equipment is present, with approximately 6-8 individuals on site, including the Contractor and Inspector.

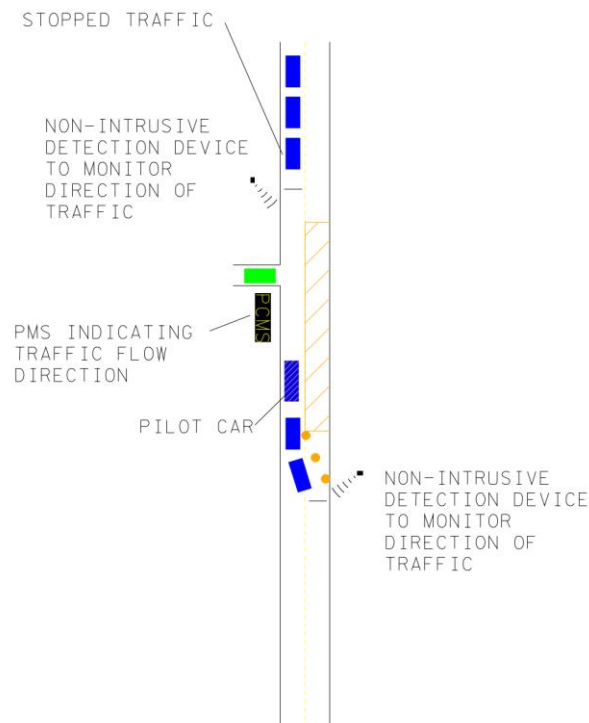


Figure 2: Rural Roadway Example

### **5.2.1 In Work Zones with Pilot Cars, Traffic Can Enter at Midpoints (From Driveways or Side Roads) and Go the Wrong Way**

In construction areas where a pilot car is needed to direct traffic on a rural roadway, Contractors must communicate with residents whose drive ways are tangent to the work zone area. The Contractor will be place detectors on the road, monitoring the direction of traffic and connect them to PCMS signs at local driveways. The PCMS signs will inform residents of the flow of traffic to prevent them from driving into the pilot car's direction when they exit their driveway. If a driver drives down the wrong direction, the detector will sound an alarm and turn on a PCMS warning sign alerting the vehicle that a pilot car is approaching. Agency or Contractor must consider all points of entry during the unconventional traffic movement and scale the system to accommodate key points where traffic can enter and go the wrong way to enhance overall safety in work zones.

### **References**

- MnDOT. (2008). *Minnesota Intelligent Work Zone Toolbox: Guideline for Intelligent Work Zone System Selection*. Retrieved March 10, 2015, from the National Work Zone Safety Information Clearinghouse: <http://www.dot.state.mn.us/trafficeng/workzone/iwz/MN-IWZToolbox.pdf>
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